Fun with Hurricane Ivan

OBJECTIVES

The student will do the following:

1. Plot the track of hurricane Ivan, the last 24 hours before landfall (2-hour intervals).

2. Determine how hurricane Ivan affected the north-central Gulf Coast.

3. Explore the relation between wind and pressure in a hurricane.

GRADE LEVEL: Late Elementary – Middle School

TIME: 45 minutes (may take longer)

MATERIALS:
Coordinates for Hurricane Ivan
Hurricane Tracking Charts
Radar Images
A weather map

BACKGROUND INFORMATION

Tropical cyclones are low-pressure weather systems with strong winds and heavy rain. There is an inverse relationship between pressure and wind speed – the lower the pressure, the higher the wind speed. Tropical cyclones occur in most ocean basins around the world. Even though the storms are the same in each basin, they are known by different terms. For instance, in the western North Pacific Ocean the storms are called typhoons. In the northern Atlantic Ocean and the eastern North Pacific Ocean regions, they are called hurricanes. The storms are known as tropical cyclones in the Indian and Australian regions.

Tropical cyclones are powered by the latent heat energy released from condensation. Surface air with enough energy to generate a tropical cyclone only exists over oceans with a temperature of at least 80°F. Ocean temperatures this high only occur in selected regions and during particular seasons. In the North Atlantic Basin, hurricane season starts on June 1 and goes through November 30; only during this time does the water warm enough for hurricanes to form.

A tropical cyclone forms when pressure is lower in the center of a storm than on the outer edge, causing strong winds around the center. Cyclones organize in a spiral as a result of the Coriolis Effect. In a mature hurricane, the storm center is cloud free and is known as the eye. This can be clearly seen in satellite photos such as Figure 1. Figure 1 shows Hurricane Ivan on September 9, 2004 at 7:00am CST (central standard time) as a category 5; the dark dot in the center is Ivan's eye. Surrounding the eye is a circular wall of strong thunderstorms known as the eyewall. This is the area where the strongest winds and the heaviest rainfall occur. Figure 2 shows a radar image of Hurricane Andrew on August 24, 1992 at 4:35am EST (eastern standard time), as it made landfall in Miami, Florida. Radar shows where raindrops (and ice particles) are located. The 'reflectivity' is measured in the units called dBZs (decibels of reflectivity), shown to the right of the radar image on Figure 2. The higher the dBZ value, the more raindrops there are. The large red and purple doughnut-shaped area in Figure 2 is Hurricane Andrew's eyewall. You can again see the eye in the center of the storm where the reflectivities are low.

Outward from the center of the hurricane, the next thing you would encounter is the moat. The moat is the region between the rainbands and the eyewall. The moat is an area of lighter rain, and on the radar image of Andrew (Figure 2) it appears in green. Surrounding the moat is a spiral shaped feature of strong reflectivities. This is a rainband. Rainbands bring heavy rain and strong winds and can even spawn tornadoes.

There are several stages in tropical cyclone development. The first stage is known as the tropical disturbance, or wave stage. A tropical wave looks like a blob of thunderstorm and has a weak wind circulation. The next stage is the tropical depression, when the winds increase to 23-39 mph (miles per hour). When the winds of a tropical depression reach 40 mph, the storm is upgraded to a tropical storm. At that time, it is also given a name. As the winds continue to increase, and reach 74 miles per hour, the storm is upgraded again, this time to a hurricane. The strongest hurricane ever recorded in the Atlantic basin was Hurricane Gilbert, September 1988. The winds in this hurricane measured up to 184 mph and the central surface pressure fell to 888 Mb.

The Saffir-Simpson Hurricane Damage Potential Scale is shown below and measures the strength of a hurricane. There are five categories on the Saffir-Simpson scale and each represents the degree of damage that occurs. The Saffir-Simpson Hurricane Scale rates hurricanes on a scale from 1-5. (See table 1.)

Hurricane Ivan evolved through all five of these categories (Figures 3 and 4), and was a category 5 hurricane when it entered the Gulf of Mexico on September 13, 2004. In the tropical depression stage, the system that would soon become Ivan looked like a white blob of clouds. The clouds soon began rotating around the central area of lowest pressure, and the winds sped up. This can be seen in images 2 and 3 (Figures 3 and 4); the Tropical Storm stage. Ivan became a category 1 hurricane on September 5, 2004. Later that day, Ivan became stronger, the pressure continued to fall, and the winds got faster, making it a category 2 hurricane; this is displayed in image 6. Notice that hurricanes might gain or lose strength many times before they dissipate. You can see the eye in that image as well.

When Hurricane Ivan made landfall in south Alabama, the wind speed was 130 mph, making it a strong Category 3 hurricane. Hurricane intensity is measured in terms of maximum wind speed or minimum central pressure. Hurricane Ivan had a central pressure of 943mb, making it a weak Category 4 (see Saffir-Simpson Scale).

What kind of damage does a strong category 3/weak category 4 do, according to the Saffir-Simpson Scale?
Did you see this kind of damage in the area you live in?

TRACKING HURRICANES

The center of the rotation, located in the middle of the eye, if there is one, marks the center of a tropical cyclone. To plot a hurricane's track, you need the latitude and longitude of the storm's center at a succession of times. The table below gives these coordinates for Hurricane Ivan in two-

hour intervals. On the map (Figure 5), try to plot Ivan's track. At what time and date did Hurricane Ivan make landfall?

Time	Date	Latitude	Longitude
1pm	9/15/2004	27.8 N	88.2 W
4pm	9/15/2004	28.4 N	88.3 W
6pm	9/15/2004	28.8 N	88.2 W
8pm	9/15/2004	29.0 N	88.2 W
10pm	9/15/2004	29.1 N	88.1 W
12am	9/16/2004	29.7 N	87.9 W
2am	9/16/2004	30.2 N	87.8 W
4am	9/16/2004	30.9 N	87.7 W
7am	9/16/2004	31.6 N	88.7 W
10am	9/16/2004	32.0 N	87.5 W
1pm	9/16/2004	32.6 N	87.1 W

WEATHER MAPS

On a weather map, meteorologists plot the temperature, pressure, and wind observed at different weather stations using a 'station plot'. The wind barb (or flags) shows the direction and speed of the wind. Each full barb represents 10 knots, half a barb is 5 knots, and a flag is 50 knots. The stem of the flag points in the direction from which the wind is blowing. A knot is a unit of measure for speed; to convert knots to miles per hour, divide the wind speed in knots by 1.15. The temperature in Celsius is on the left side of the plot and the pressure in millibars is on the right.

Can you tell what the wind direction, and wind speed in knots and mph, temperature, and pressure are at the station in Figure 6?

ADVANCED PREPARATION

1. Obtain Hurricane Tracking Charts, enough for each student in your class. These can be downloaded at: http://www.nhc.noaa.gov/AT_Track_chart.pdf and copied. The larger the papers size the better.

2. Obtain copies of this curriculum piece in addition to the Fun with Hurricane Ivan student worksheet and copy enough for each student in your class. You will see overlap between the two pieces.

PROCEDURE

This curriculum piece can be done as an in class project with discussion or homework assignment.

RESOURCES

Hurricane Tracking Chart http://www.nhc.noaa.gov/AT_Track_chart.pdf
Teachers First.Com http://www.teachersfirst.com/storm.shtml
National Weather Service http://www.nws.noaa.gov/
NASA Explores Hurricane Tracking
http://www.nasaexplores.com/show_912_teacher_st.php?id=030108135723
Mobile Bay National Estuary Program http://www.mobilebaynep.com
University of South Alabama Earth Science Department http://www.southalabama.edu/geography
Dauphin Island Sea Lab http://www.disl.org

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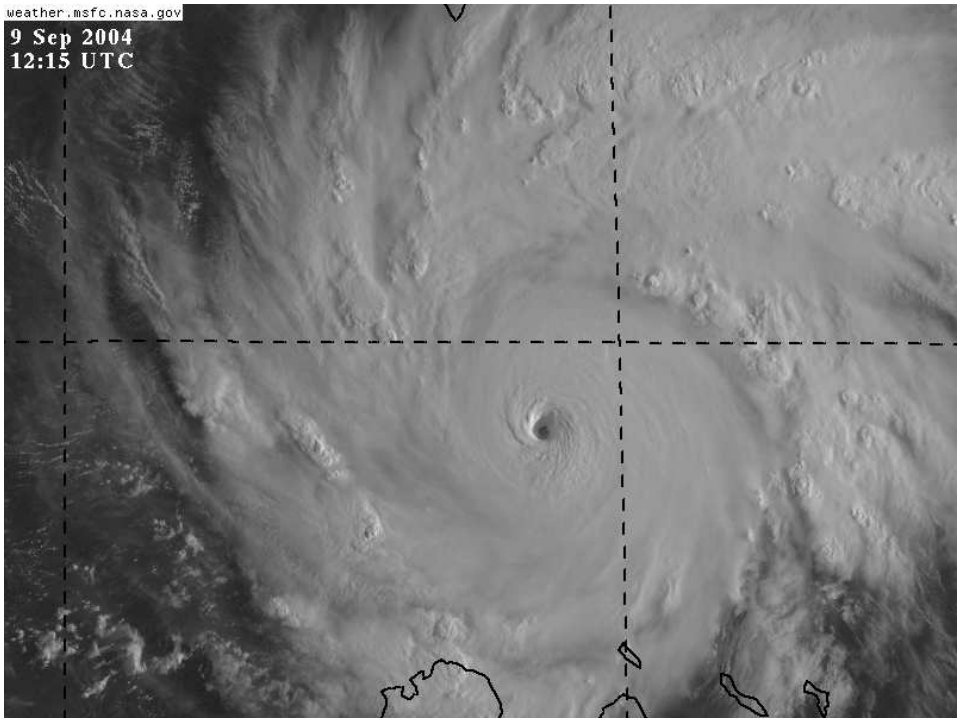

Figure 1: Visible satellite image of Hurricane Ivan in the Caribbean Sea on September 9, 2004 at 8:15am EDT. (Courtesy of weather.msfc.noaa.gov)

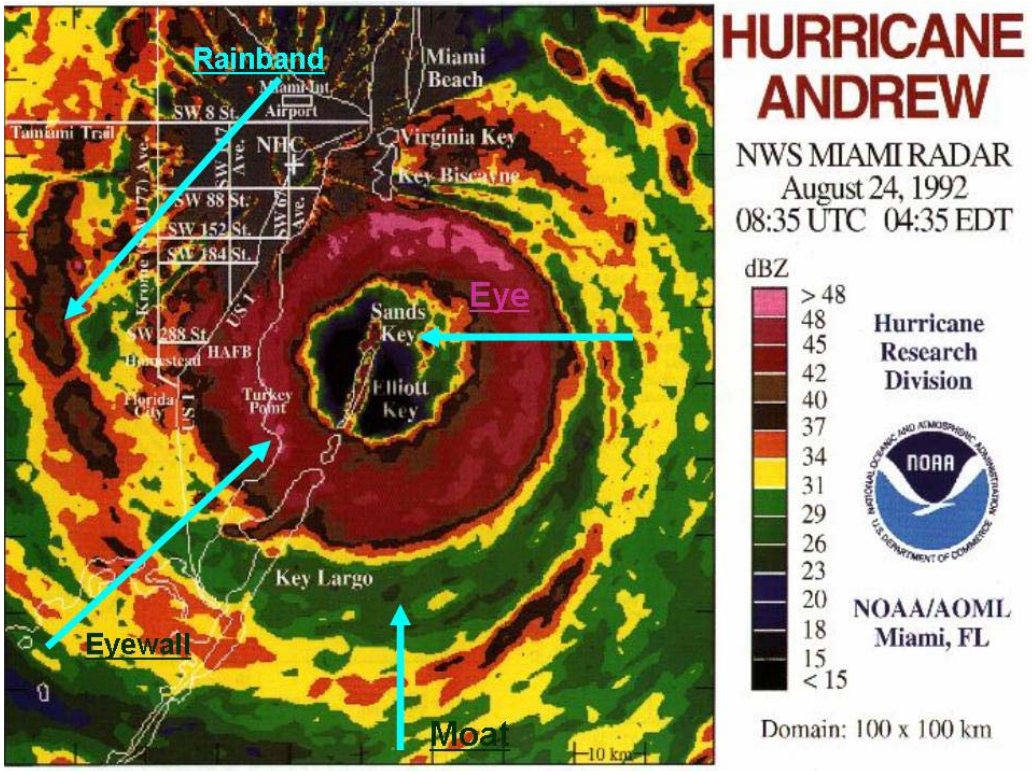

Figure 2: Hurricane Andrew at landfall on August 24, 1992 at 4:35am EDT. (Courtesy of the Hurricane Research Division)

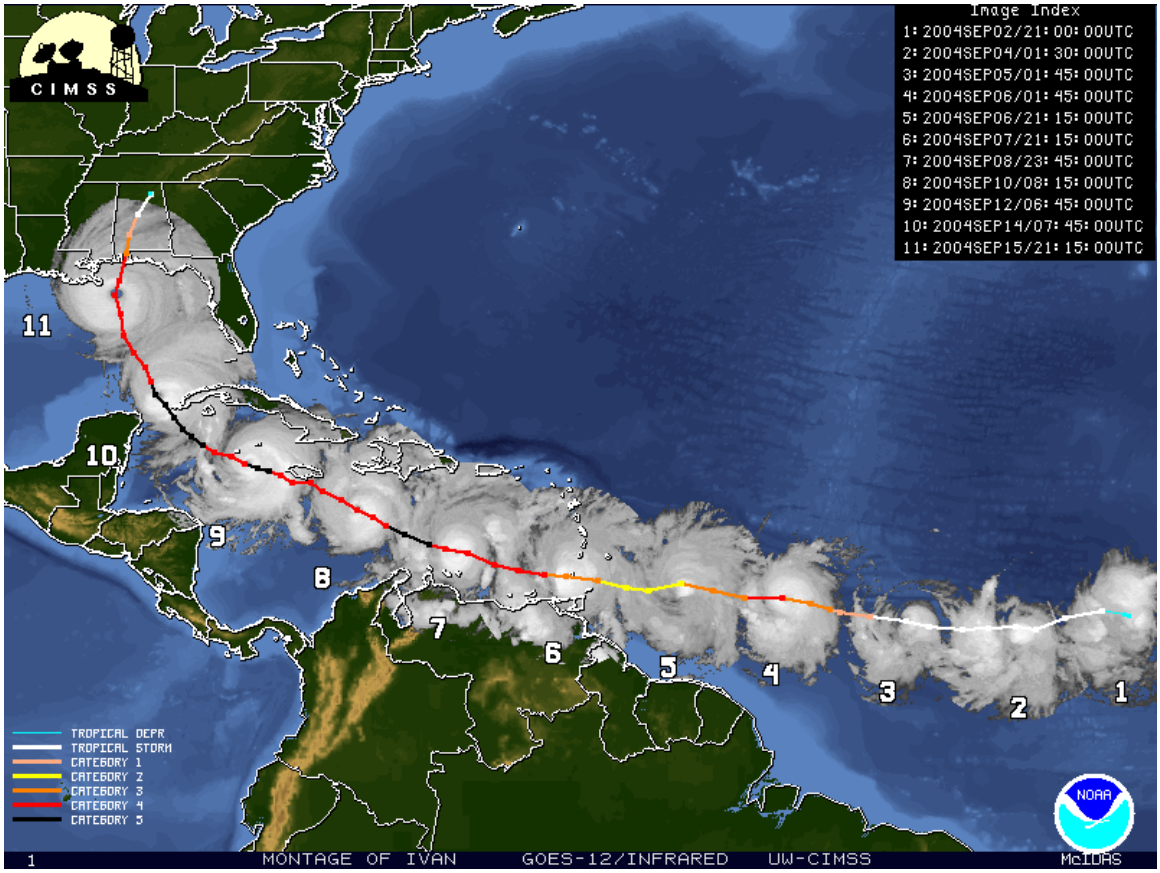

Figure 3: This is a satellite image of Hurricane Ivan, from the tropical depression stage through the final landfall over Southwest Alabama. The colored track shows the different stages of development. Blue (1) is a Tropical Depression. White (2 and 3) Tropical Storm. Peach (between 3 and 4), Category 1 hurricane. Yellow (5), Category 2 hurricane. Orange (6), Category 3. Red (8), Category 4. Category 5 (10), black. (Courtesy of CIMSS)

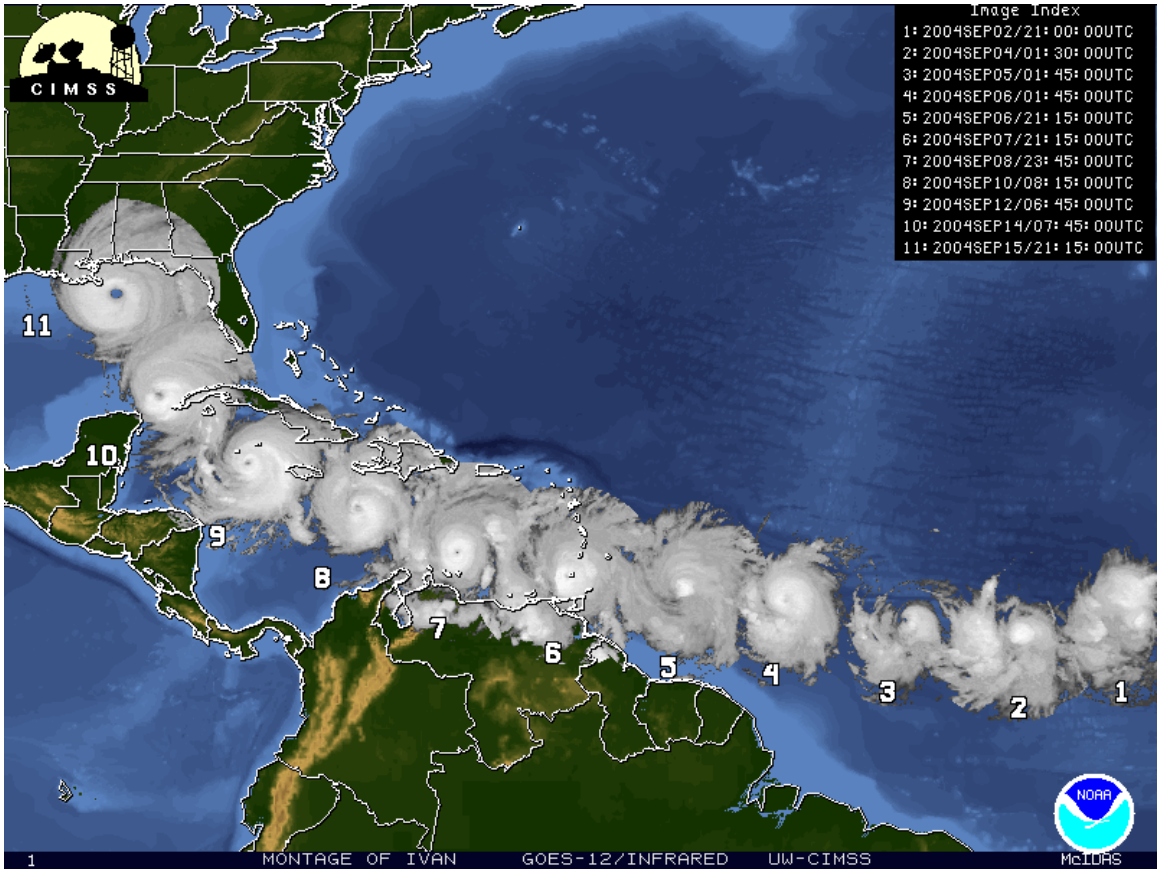

Figure 4: As in Figure 3, but without the colored storm track. (Courtesy of CIMSS)

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Category	Wind	Pressure	Damage
1	74-95 mph	≥ 980 Mb	Trees, shrubbery, and unanchored trailers
2	96-110 mph	965-970Mb	Small trees are blown down, major damage to trailers, and some damage to roofs of buildings.
3	111-130 mph	945-964 Mb	Leaves removed from trees, large trees blown down, trailers destroyed, some structural damage to small buildings.
4	131-155 mph	920-944 Mb	Signs blown down, heavy damage to roofs, windows, doors complete damage to trailers, flooding as far inland as 6 miles, and major damage to lower floor of buildings near the shore.
5	>155	≤ 920 Mb	Severe damage to windows, and doors, extensive damage to roofs of homes and other buildings, small buildings overturned and blown away, major damage to the lower floors on all structures less than 15 ft above sea level, within a ½ of a mile from the shore.

Table 1: Saffir-Simpson Scale

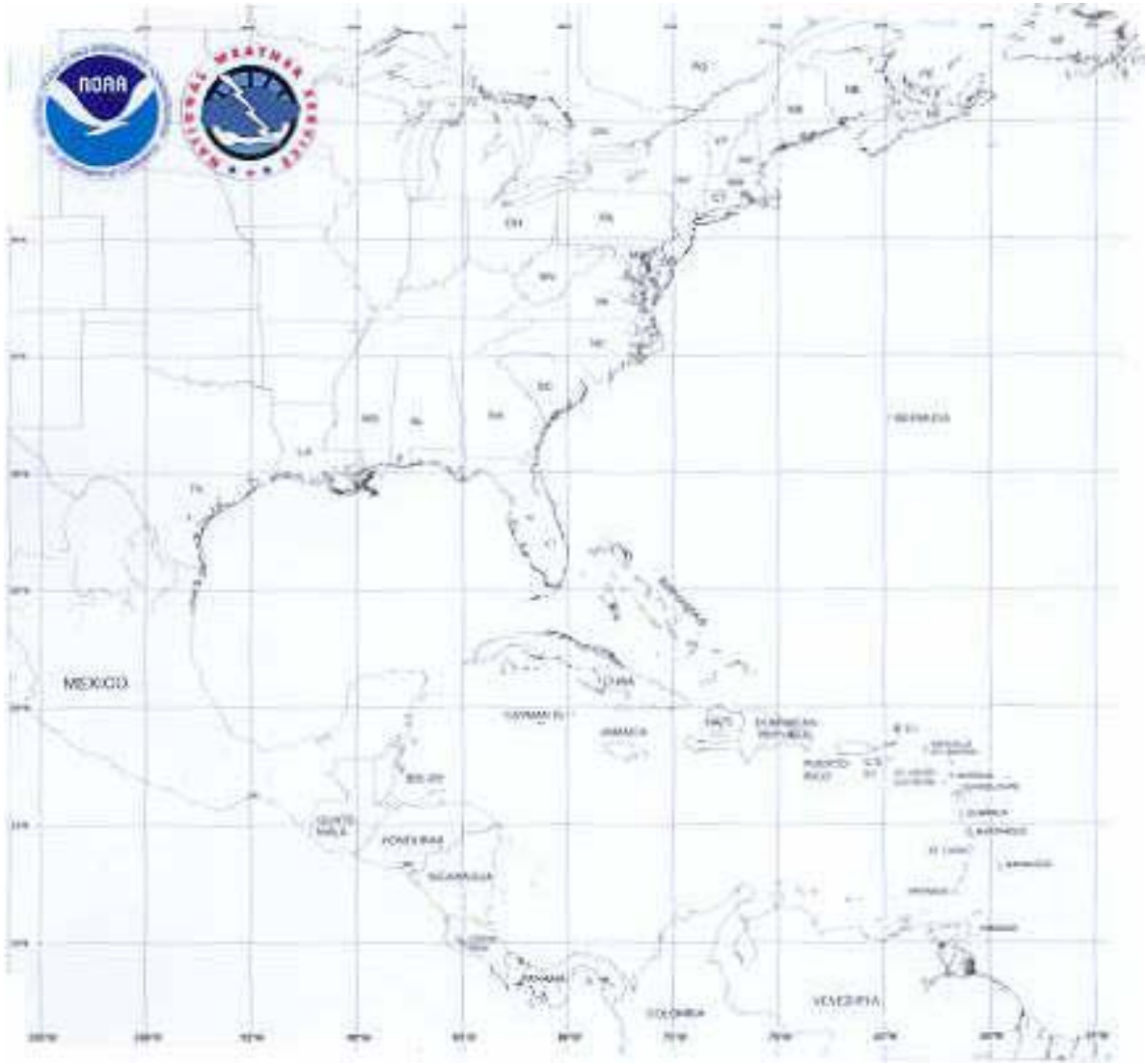
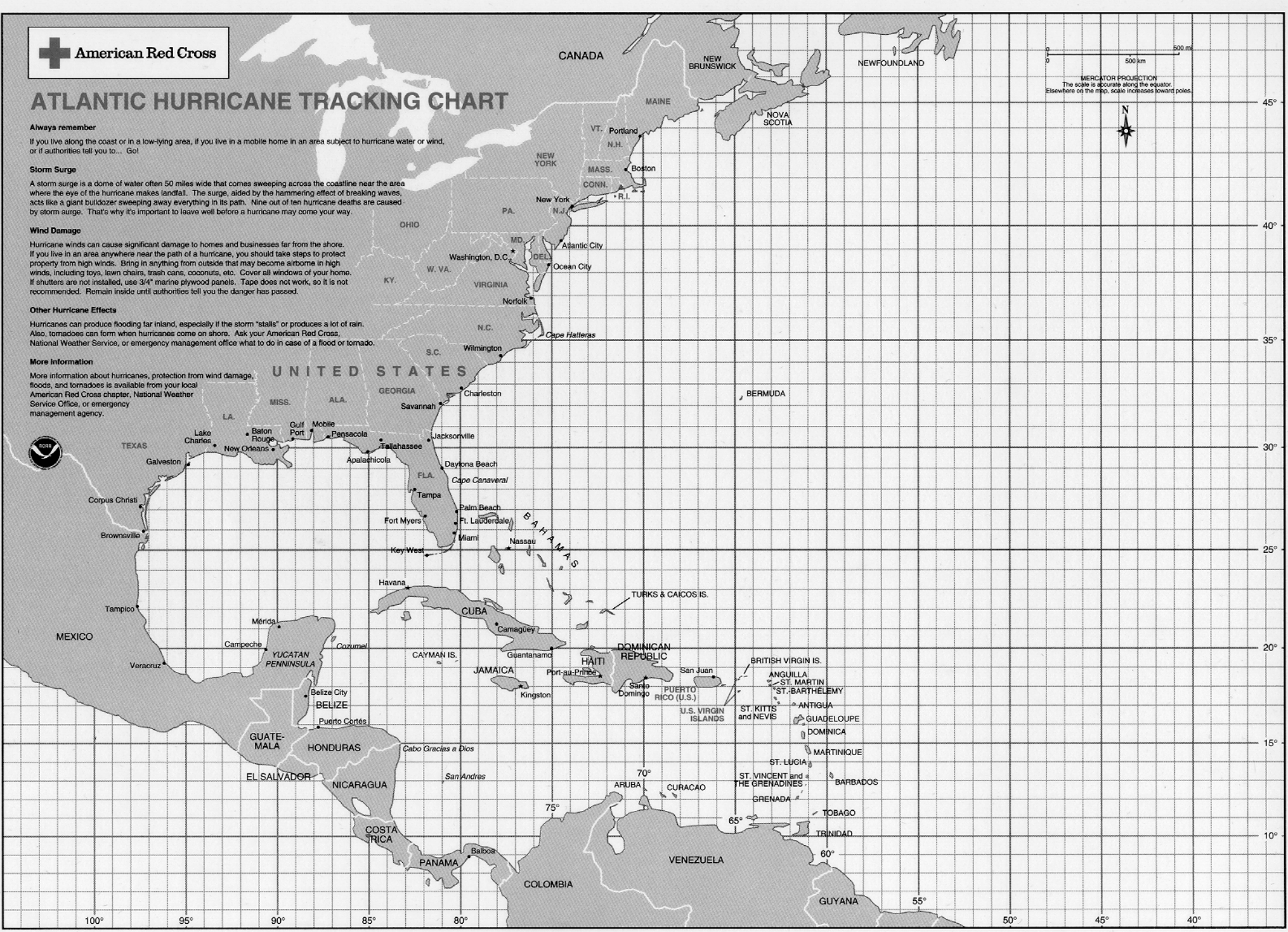


Figure 5: Hurricane Tracking Chart to plot Hurricane Ivan - http://www.nhc.noaa.gov/AT_Track_chart.pdf



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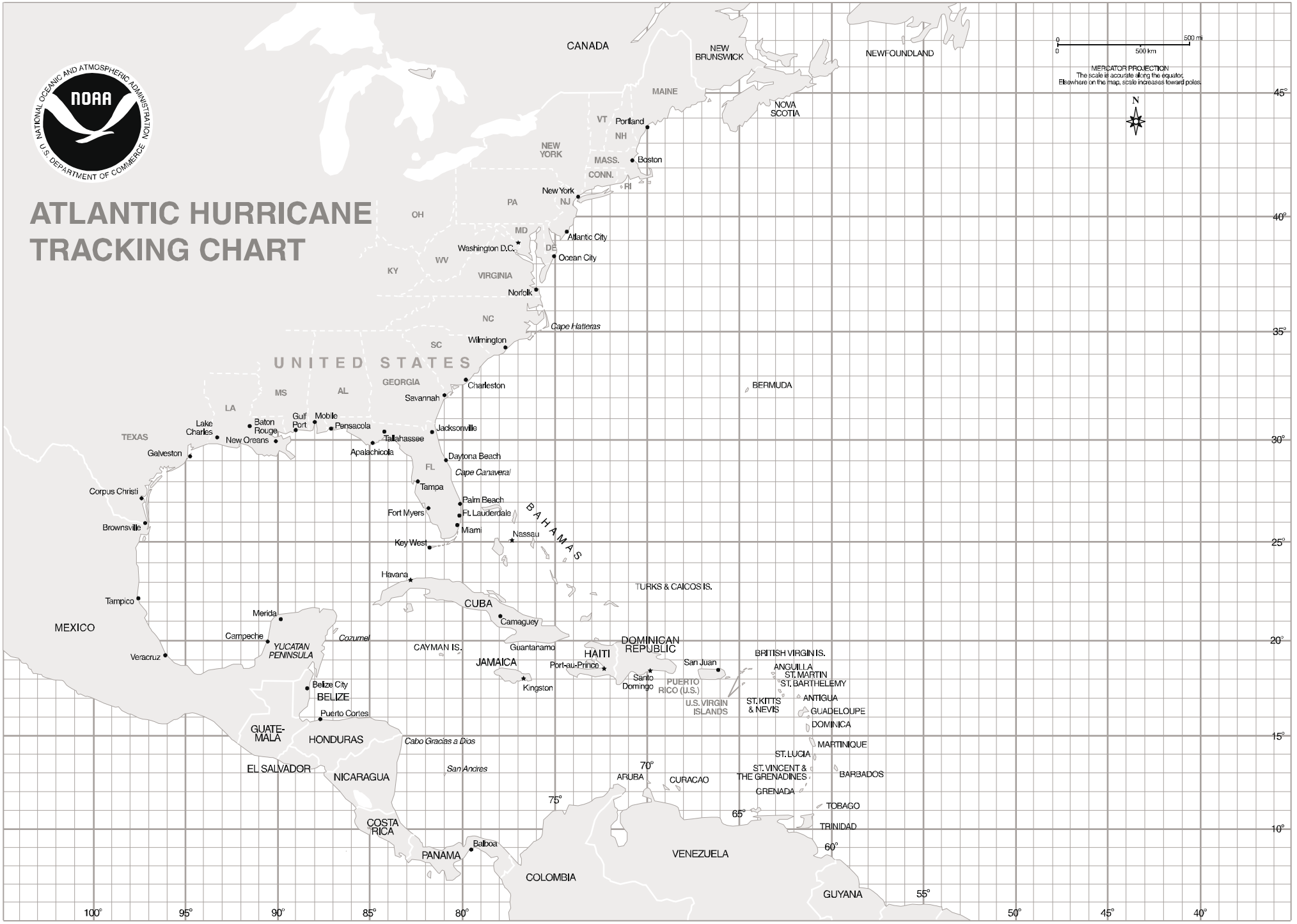
ATLANTIC HURRICANE TRACKING CHART
NOAA
NATIONAL OCEANIC AND ATMOSPHERIC ADMINISTRATION
U.S. DEPARTMENT OF COMMERCE
MERCATOR PROJECTION
The scale is accurate along the equator.
Elsewhere on the map, scale increases toward poles.
0 500 mi
0 500 km
N
CANADA
NEW BRUNSWICK
NEWFOUNDLAND
NOVA SCOTIA
MAINE
VT
NH
MASS.
CONN.
RI
NEW YORK
PA
NJ
OH
MD
DE
WV
KY
VIRGINIA
NC
SC
GEORGIA
MS
AL
LA
TEXAS
UNITED STATES
Portland
Boston
New York
Atlantic City
Washington D.C.
Ocean City
Norfolk
Cape Hatteras
Wilmington
Charleston
Savannah
Jacksonville
Gulf Port
Mobile
Pensacola
Tallahassee
Apalachicola
Lake Charles
Baton Rouge
New Orleans
Galveston
Daytona Beach
Cape Canaveral
Tampa
Palm Beach
Fort Myers
Ft. Lauderdale
Miami
Key West
Corpus Christi
Brownsville
BERMUDA
BAHAMAS
Nassau
Havana
TURKS & CAICOS IS.
CUBA
Camaguey
Tampico
Merida
MEXICO
Campeche
YUCATAN PENINSULA
Cozumel
Veracruz
CAYMAN IS.
Guantanamo
JAMAICA
Kingston
HAITI
Port-au-Prince
DOMINICAN REPUBLIC
Santo Domingo
PUERTO RICO (U.S.)
San Juan
U.S. VIRGIN ISLANDS
BRITISH VIRGIN IS.
ANGUILLA
ST. MARTIN
ST. BARTHELEMY
ST. KITTS & NEVIS
ANTIGUA
GUADELOUPE
DOMINICA
MARTINIQUE
ST. LUCIA
ST. VINCENT & THE GRENADINES
BARBADOS
GRENADA
TOBAGO
TRINIDAD
ARUBA
CURACAO
VENEZUELA
GUYANA
COLOMBIA
Belize City
BELIZE
Puerto Cortes
GUATE-MALA
HONDURAS
Cabo Gracias a Dios
EL SALVADOR
NICARAGUA
San Andres
COSTA RICA
PANAMA
Balboa
100°
95°
90°
85°
80°
75°
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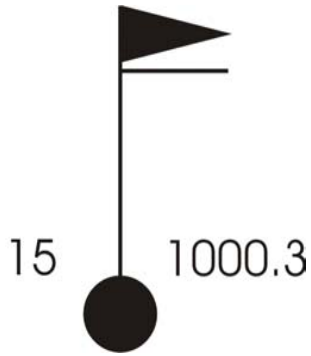

Figure 6: Sample Surface Plot

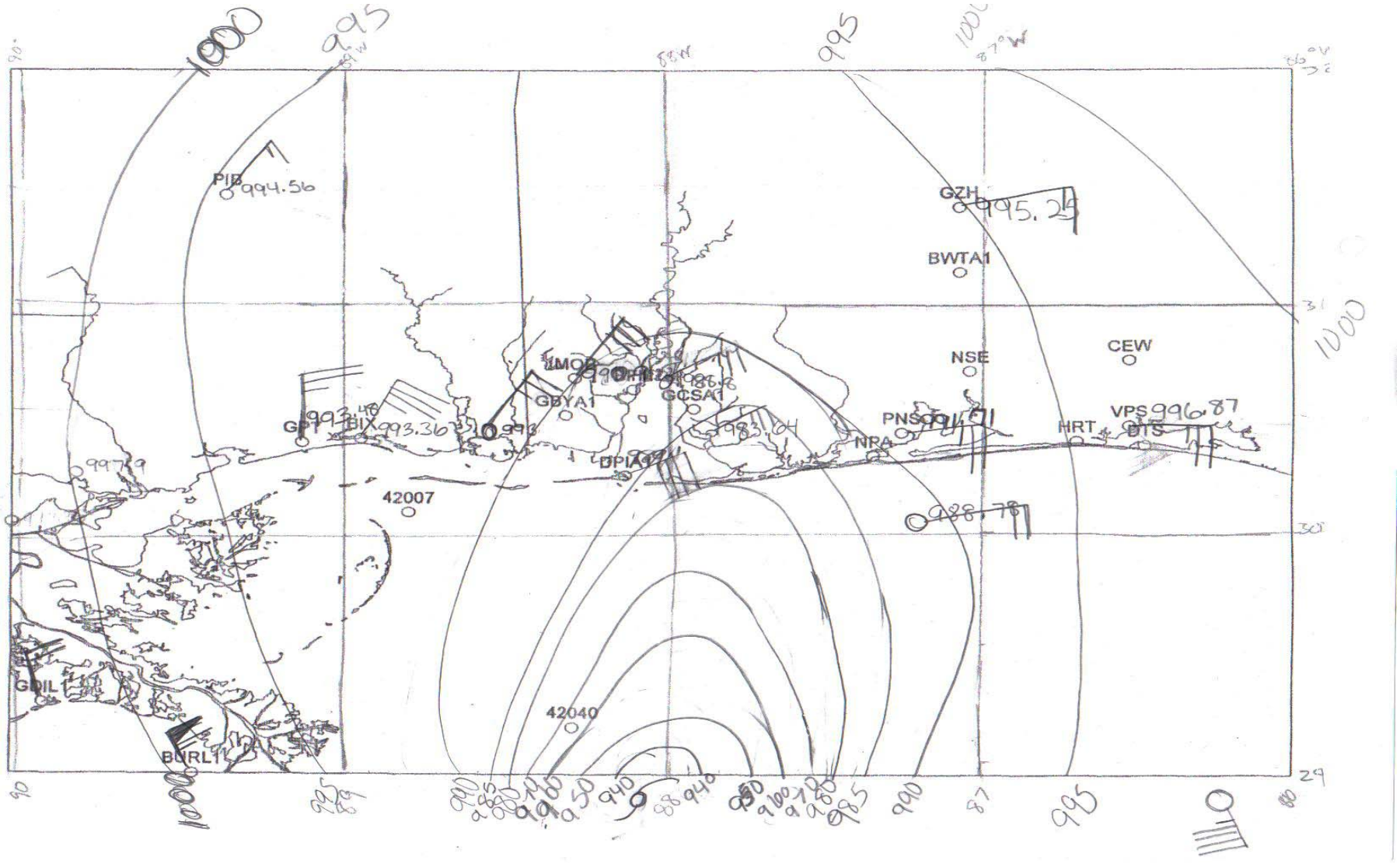

Figure 5: 8:00 pm surface chart with station plots and Hurricane Ivan in the Gulf of Mexico

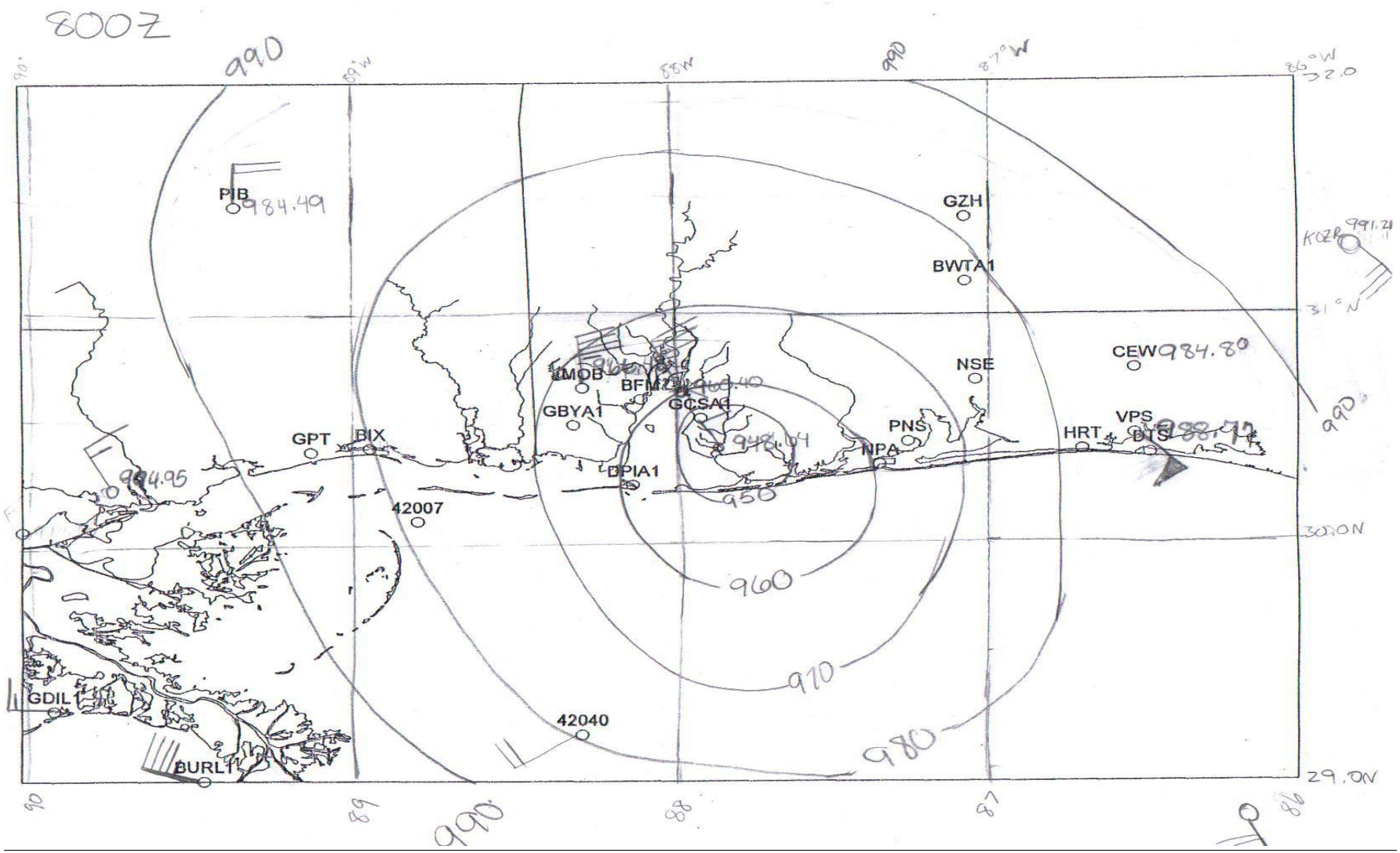

Figure 6: 2:00 AM surface map with station plots and Hurricane Ivan on shore